SPONSORED BY

NSF

DATA AND RESEARCH WORKSHOP

OCTOBER 24-26, 2012 • TULUM, YUCATAN, MEXICO

COCONet

CONTINUOUSLY OPERATING CARIBBEAN GPS OBSERVATIONAL NETWORK

The COCONet 3rd workshop was supported by NSF-EAR Instrumentation and Facilities Award #1042906 to UNAVCO.

The COCONet project was awarded by the National Science Foundation to UNAVCO and UCAR with formal participation by Purdue University and the University of Houston. Its success hinges on engagement and participation by an international community of scientists with interests in the Caribbean region and geodesy.

UNAVCO

UCAR
UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

UNIVERSITY of HOUSTON

PURDUE UNIVERSITY

Workshop Organizing Committee

- **Alberto M. López-Venegas** (Chair) PRSN-UPRM, Puerto Rico, USA
- **Enrique Cabral-Cano** (Co-chair) Instituto de Geofísica-UNAM, México
- **Eric Calais** Purdue University, Indiana, USA
- **Karl Feaux** UNAVCO, Colorado, USA
- **Lloyd Lynch** UWI-SRC, Trinidad & Tobago
- **Héctor Mora-Páez** Servicio Geológico Colombiano, Colombia
- **Andrea Sealy** CIMH, Barbados
- **Guoquan Wang** University of Houston, Texas, USA
- **Paquita Zuidema** RSMAS, University of Miami, Florida, USA

The workshop report was prepared by the organizing committee and was edited by Glen S. Mattioli, M. Meghan Miller, and John Braun. Final production was done by Megan Berg.

COCONet
CONTINUOUSLY OPERATING CARIBBEAN GPS OBSERVATIONAL NETWORK

Table of Contents

SECTION 1: Introduction

The third COCONet workshop, held in Tulum, Mexico (October 24-26, 2012), was sponsored by the National Science Foundation and hosted by the National Autonomous University of Mexico (UNAM) and UNAVCO. The Tulum meeting included 84 participants, representing 45 institutions from 19 countries. This report details the activities and outcomes of the workshop. Appendix A lists the 3rd workshop organizing committee, Appendix B contains the workshop agenda, and Appendix C provides a list of workshop participants.

The original COCONet proposal envisioned supporting two workshops over the planned project life of three years. The original time-line for COCONet was expanded to five years 2011 and the end date for the project is now August 31, 2015. The original plan to hold a project kickoff meeting in year one and a network operators meeting in year three was expanded to a total of three workshops. Additional funding was provided by NSF to expand participation in the first COCONet workshop, and funds were reallocated from the project budget to expand participation in the third workshop. During the first workshop, held in San Juan, Puerto Rico (February 3-4, 2011), participants developed an initial community plan that refined the overarching science goals for the proposed integrated multi-disciplinary network, reviewed the original GPS station siting plan, developed a consensus list of existing high-quality cGPS stations in the Caribbean for possible inclusion into the COCONet archiving and data processing scheme, and defined and prioritized additional science experiments, which could capitalize on the NSF investment in the pan-Caribbean infrastructure of COCONet.

The second workshop, held in Port-of-Spain, Trinidad, Republic of Trinidad and Tobago (June 28-29, 2011) brought together Caribbean network operators to evaluate and select existing and new stations to meet the COCONet science goals and to begin planning for pan-Caribbean capacity building with a focus on data collection, processing and archiving. GPS network operators identified numerous existing stations in the Lesser Antilles and Venezuela, which were not previously known by the larger geodetic community or UNAVCO staff; developed a first-order siting plan for new stations; clarified the need for a follow-on siting meeting to identify and finalize existing and new station locations. In addition, both Caribbean and US investigators requested that the COCONet management team consider a refurbishment option for some set of regional GPS stations of geodetic quality, which require equipment upgrades to be at COCONet standards.

This third COCONet workshop focused primarily on longer-term operations and maintenance for GPS stations installed in the Caribbean, GPS data processing, generation of higher-level data products, and real-time GPS data distribution for enhanced science and broader societal benefits. Several examples of recent scientific advances and societal benefits arising from the nascent stages of COCONet were presented by invited speakers. In addition, there were presentations about the future, potential, and long-term sustainability of COCONet data and the COCONet user community. Plans to establish regional data centers (RDC) for raw data archival, basic data analysis, and enhanced data products were proposed and discussed during several breakout sessions. An overarching goal of any COCONet RDC is to advance not only regional capacity, but to further enhance regional use and impact of COCONet data. A key result of the Tulum meeting was identification of several institutions, which could host a regional data center. Representatives from these institutions will be invited to a smaller meeting, likely to be hosted at UNAVCO

headquarters in Boulder, CO, in the next 3-6 months to develop further the technical requirements and implementation plans for COCONet RDCs. Other key objectives of the meeting were to explore new research opportunities and data products and to map out future goals and expanding directions for COCONet. There was great enthusiasm and energy at the workshop from all of the participants to develop regional data centers, to advance COCONet research and educational opportunities, to enhance regional science and engineering workforce capacity, to improve and strengthen international partnerships, and to promulgate the societal benefits arising from COCONet.

COCONet Siting and Station Construction Status

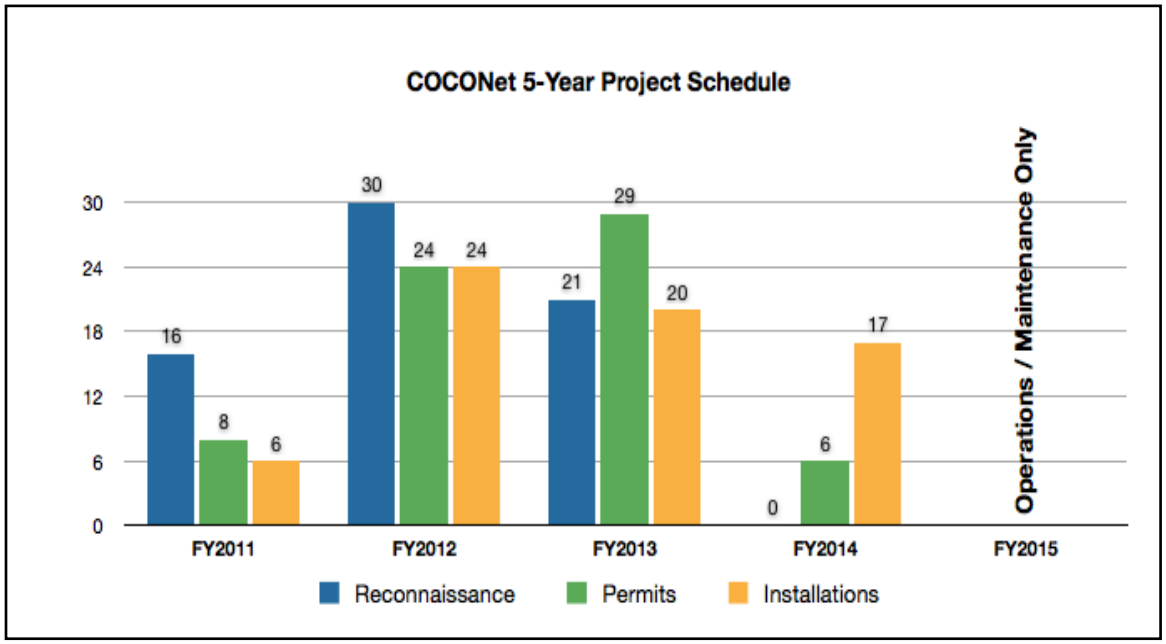

Figure 1. The current COCONet 5-Year project schedule, showing yearly goals for reconnaissance, permitting, and station installations. The revised siting plan calls for 67 station installations (46 new and 21 refurbished).

The Tulum workshop provided an opportunity for participants to learn more about the status of reconnaissance, permitting, and station installations for COCONet. The five-year project plan, which was developed after the Trinidad meeting, includes four years (FY2011-FY2014) of station construction activities and one year (FY2015) of operations and maintenance (Figure 1). The siting plan that was developed at the Trinidad meeting consisted of 50 new stations, 15 refurbished stations, and at least 61 existing stations from the region to be incorporated into the COCONet archive and processing. The COCONet Siting Committee, which was formed in August 2011 as a recommendation from the Trinidad meeting, has approved removal of four new stations from consideration, while recommending additional investment in refurbishing existing stations in the region. The siting session at the Tulum workshop was productive, resulting in clarification of the status of the existing COCONet station in Honduras (TEG2) and the elimination of three existing stations for consideration from the Trinidad siting plan. The revised plan now consists of 46 new stations, 21 refurbished stations, and 77 existing stations to be incorporated into the COCONet data archive and processing.

The COCONet project is entering its third year of construction and significant progress has been made in reconnaissance, permitting, and station installations (new and refurbished). Overall, the project is ahead of schedule in reconnaissance and permitting and slightly behind schedule in station installations. For the 67 new and refurbished stations, the project has completed 57 reconnaissance visits, accepted 37 permits, and installed 28 stations (Figure 2). Data from 45 existing regional stations have been delivered to the COCONet archive (Figure 3). With the progress made to date, the COCONet project is in a good position to meet the four-year construction goals on-schedule and within budget.

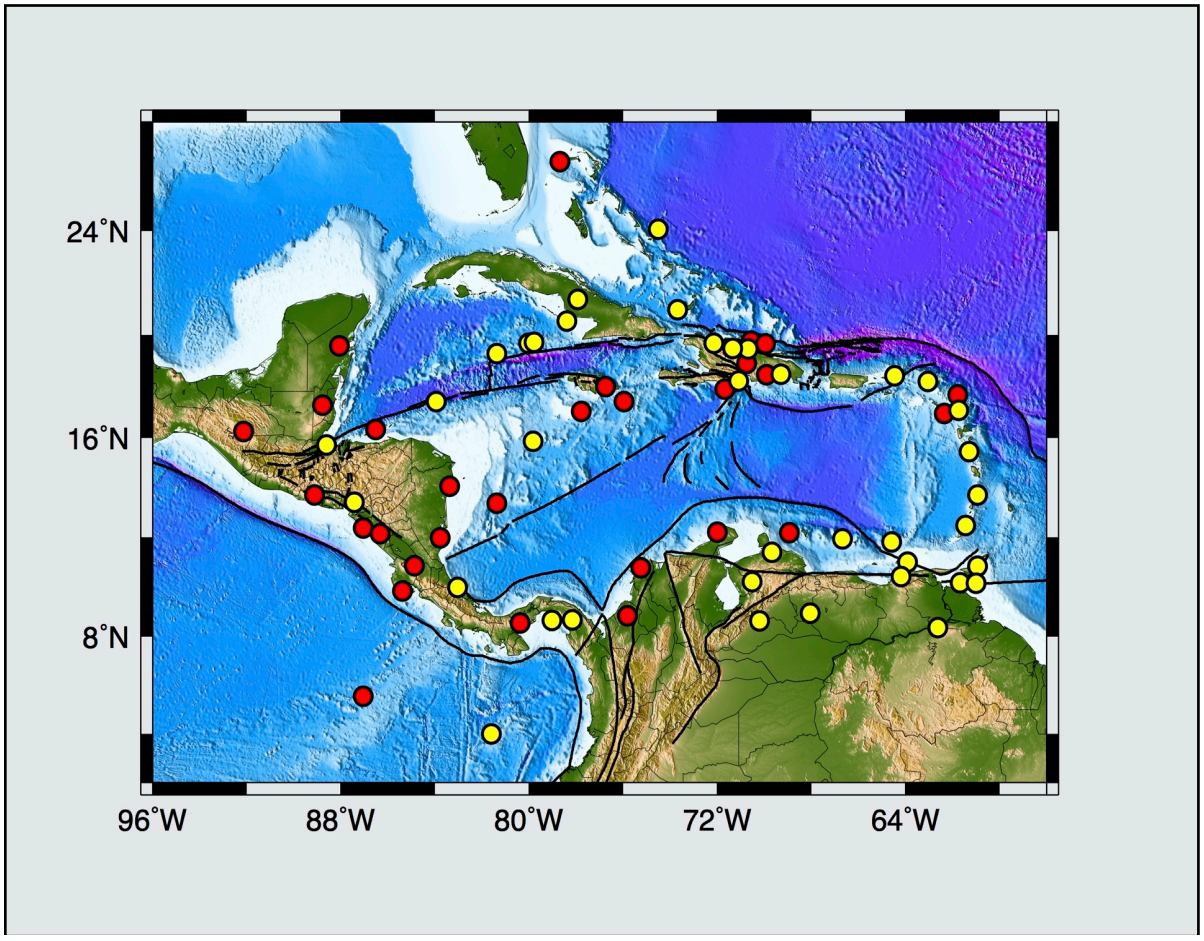

Figure 2. Status of new and refurbished stations. The 28 red dots represent installed stations. The 39 yellow dots represent stations to be installed in the next two years.

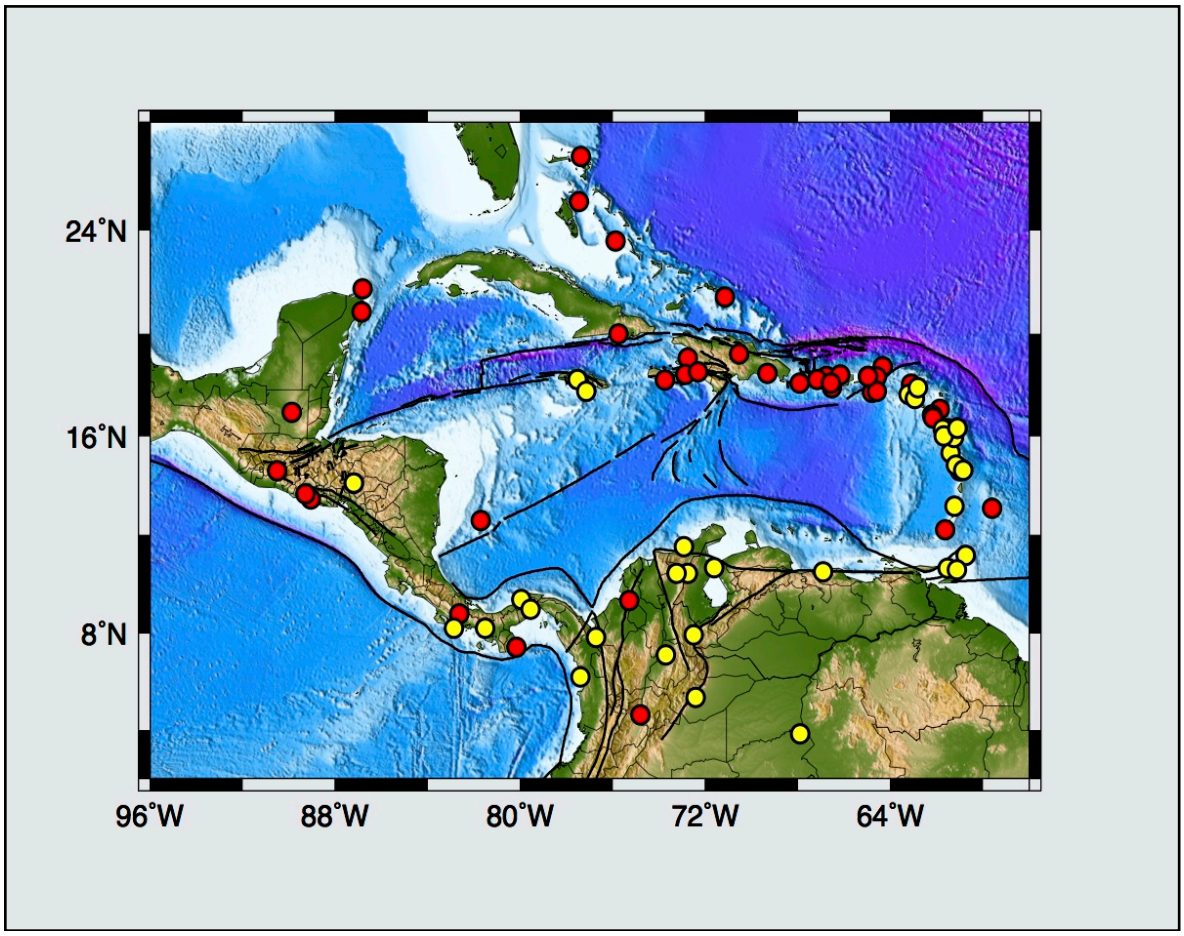

Figure 3. Status of existing stations. The 45 red dots represent stations delivering data to the COCONet archive. The 32 yellow dots represent stations not yet delivering data to the COCONet archive.

SECTION 2: Summary of Recommendations from Past Meetings

A list of recommendations from the Trinidad & Tobago meeting is reproduced below along with the actions that have taken place since then in response to the recommendations (shown in **bold**).

1. *Develop a four-year plan for a series of short courses and international exchanges focused on GPS infrastructure and data management, applications across the geosciences, and topics that will support return on COCONet infrastructure and data sets. The plan should explicitly include a role for international students and post-docs, including training exchanges. This will require identification of funding for collaborative exchange among researchers.* **A plan to address this recommendation has not yet been fully developed, although we have made substantial progress. Similar recommendations were suggested during the 3rd workshop. Although UNAVCO has offered short courses in the past addressing similar issues, no short courses have been offered by UNAVCO that focus specifically on the COCONet community and its needs. A plan to engage international students and post-docs from the COCONet community still remains to be fully developed. Two NSF-PASI workshops (one on magma-tectonic interactions, lead by P. LaFemina, and another on atmospheric processes, lead by J. Braun) have been funded and these were announced at the Tulum meeting. Registration for both PASI workshops is now open.**

2. *Build a community web portal so that institutions and countries can effectively share information about priorities, capabilities, and needs in the areas of communication facilities, locations, management/contact information, data availability, educational resources, partnerships, and other topics of mutual interest. Web portal functionality as ranked by responses from the workshop survey includes:*
    - *Information about data availability (9)*
    - *General information sharing (7)*
    - *Site information and status (7)*
    - *Links to disaster risk reduction information and organizations (7)*
    - *Remote on-line training (7)*
    - *Linkages to partner organizations (6)*
    - *A repository of regionally-focused educational materials (6)*
    - *Technical information about networks and communication systems (5)*
    - *Community calendar (4)*
    - *Sharing of stories and pictures (4)*
    - *Specialized data information access for teachers, surveyors or planners (4)*

    This recommendation has been successfully implemented. A COCONet web portal was established following the 2Nd meeting in Trinidad & Tobago. The web address is http://coconet.unavco.org **and it features most of the functionalities listed above. Links to the two NSF-PASI workshops described above are also available on the COCONet web portal.**

3. *Identify an operator in each country hosting COCONet infrastructure to be a local leader and point of coordination between COCONet and in-country geodesy stakeholders (including existing networks, survey organizations, universities, earthquake agencies emergency planners, etc.).* **A liaison in each host country has been identified, and the local POC will be formalized once all sites have been installed.**

4. *Secure funding to establish disseminated regional data archives and processing centers for COCONet solutions, located within the circum-Caribbean region and providing access, products, and instrument pools for regional campaign studies. This initiative should build on UNAVCO's seamless archive capabilities and on established pathways for data processing of large networks. This initiative could also be used to advance strategic partnerships among Caribbean nations.* **This recommendation was the primary scope of the 3rd workshop. Recommendations to fulfill this goal have been refined and an action plan has been developed for the implementation of one or more data centers in the region (see Section 4.4: Recommendations for a Regional Data Center).**

5. *Establish a working group to define the Caribbean reference frame and to coordinate with SIRGAS and SNARF.* **A SIRGAS representative was invited to attend the 3rd COCONet workshop. Unfortunately, the SIRGAS annual meeting was scheduled the week following the 3rd COCONet workshop, resulting in the inability of a SIRGAS representative to attend. However, the UNAVCO Director of Geodetic Infrastructure and COCONet Co-PI, G. Mattioli, attended the SIRGAS2012 meeting in Concepcion, Chile, where he presented a talk on the status and scientific motivation behind COCONet. In addition, COCONet sites are being processed by the PBO Analysis Centers, and combined and transformed into an IGS08-defined Caribbean-fixed frame. Coordination with SNARF, per se, has not occurred, as the PBO GPS Data Products Working Group is in the process of evaluating SNARF as the PBO standard for the North America-fixed frame.**

6. *Develop stakeholder-informed best practices for COCONet construction, management, and dataflow. Identify resources for local operators to access technical support to solve relatively minor technical issues.* **This has been occurring on an individual basis with several members of the COCONet community, but has not been implemented widely for all regional stakeholders and data providers.**

7. *Establish vibrant and visible intellectual and professional connections that supersede political barriers, and focus on common science and societal impact goals (e.g. regionally coordinated plans for tsunami warning) shared among the international participants.* **Connections within the COCONet community are starting to flourish, albeit at a slow pace. We believe, however, that these connections will be more robust and visible as data from an increasing number of new COCONet stations become available**.

8. *Web site resource that would address this topic includes (1) links to disaster risk reduction information and organizations; (2) specialized data information access or teachers, surveyors or planners; and (3) a repository of regionally focused educational material. The latter two would require specific proposals or new resources for implementation.* **No action has yet occurred with regard to this recommendation. Efforts to involve the UNAVCO Director of External Affairs will be increased going forward.**

9. *Develop pathways for data and science to inform governments and agencies on natural hazards.* **No action has yet occurred with regards to this recommendation; however, the same recommendation has also been suggested from participants of the 3rd workshop. In addition, see comments above regarding an enhanced role of the EA Director in COCONet activities.**

10. *Identify resources to develop real-time data streams and data access customized for users in surveying, planning, hazards, primary education and other specialties identified in conversations with regional and local stakeholders.* **Some high-rate, real-time GPS users have been identified so far, but comprehensive list of possible stakeholders within the COCONet community has yet to be identified.**

SECTION 3: Meeting Description

The Tulum meeting was designed to provide participants with an update on the current status of the project, to solicit their feedback regarding its implementation and execution, and to look forward and identify specific tasks, which need to be completed to ensure that COCONet meets its stated sciences and community development objectives as well as to build a research-grade geodetic network to support the international natural hazard research community. From the initial planning stage, the meeting was designed to be an interactive event. There were sessions organized around oral presentations, group breakout sessions designed to solicit feedback on how the project might be improved, followed by a wrap up session that focused on identifying the necessary steps forward. The agenda for the workshop is included in Appendix A.

3.1 Session Descriptions

Brief descriptions of the sessions are provided below.

Session I "Project Evaluation: Accomplishments and path forward" included an update on the current state of the project, summarizing instrument installations, permits accepted, and soliciting feedback regarding the overall progress to date.

Session II "Data" took a broad look at what data COCONet is producing, how to assess its quality, and ways in which the data may be used for various scientific investigations. This session also included atmospheric and solid earth science breakout sessions, which allowed meeting participants a chance to provide input on data requirements, standards, accessibility, and usability by the research community.

Session III: "Research" was focused on how COCONet data products are being, and might possibly be, used for atmospheric and solid earth science research. This session was enhanced with breakout sessions to capture input from the meeting participants.

Session IV: "Sustainability and Capacity Building" included a strategic discussion about what is needed to advance COCONet towards a project that is more fully embraced by the regional community. This session included guidance and advice from program managers from the National Science Foundation, discussions about existing regional partnerships, and updates of two upcoming Pan American Advanced Studies Institutes (PASI), both of which emphasize COCONet science.

Session V: "Regional Data Center" was a broad discussion about how to create regional data centers that are maintained and operated by host institutions in the Caribbean and Latin America. This session also ended with a group discussion that served to summarize the principle outcomes, accomplishments, and tasks that came out of the meeting.

3.2 Future Events related to COCONet

Through a combination of external proposals being submitted to build capacity in the Caribbean and Latin America, as well as the routine schedule of scientific meetings, a number of events related to COCONet were identified in Tulum. Two PASI courses associated with COCONet have been funded. Both of these courses are nominally two weeks in duration, with funds available to support approximately 30 students. These students will be chosen from a competitive selection

process, with a participant population comprised equally of US and international students, post-docs, and early career scientists. All participants receiving support from NSF funds must be either from the US, Latin America, or the Caribbean. The first course is entitled "Magma-Tectonic Interactions in the Americas." This course will be held in Leon, Nicaragua from May 5 - 18, 2013. The second course will be entitled "Atmospheric Processes of Latin America and the Caribbean: Observations, Analysis, and Impacts." It will be held in Cartagena, Colombia from May 27 – June 7, 2013. The AGU Meeting of the Americas (MoA) will be held in Cancun, Mexico from May 14 - 17, 2013. At least two COCONet- related sessions have been proposed for this meeting. The MoA provides an early opportunity to evaluate the impact that COCONet has been able to make in improving the scientific capacity of the region.

3.3 Workshop Discussions for Solid Earth applications

3.3.1 Research Objectives

Scientific and research objectives in Circum-Caribbean countries are typically driven by specific needs, which when identified, raise the opportunities for agencies/institutions or individual researchers in a country to achieve scientific objectives. During the discussion session, the community raised several issues related to those needs, which can be summarized into four main categories:

1. Technical knowledge: An increased interest in enhancing the ability to use and process the data. Operators from various Caribbean networks lack the necessary expertise for taking full advantage of COCONet data, hence technical and specialized skills are in demand. These technical needs include but are not limited to:
   a. Data transmission: Uncertainty in the selection and methodology necessary for assuring effective and efficient form of bringing the data from site to user.
   b. Data processing: Ability to install and use available software to analyze data and obtain results associated to earthquake studies and urban geological hazards, among others.
   c. Data modeling: Interest in moving a step further and use available software to model various geologic processes. Many regional scientists are eager to collaborate with other researchers and institutions to learn how to generate models for various geologic hazards.
   d. Networking: Take advantage of social networks, forums, e-mail listservers, blogs, and other multi-user interactive tools for promoting the exchange of knowledge, information, advice, and contributions. These resources are valuable to new users by providing positive transfer of knowledge and ensure that errors and mistakes done in the past are not repeated.
   e. Dissemination: Make use of new technical advances to reach out to the public. These include webinars, videoconferences, on-line tutorials, monthly newsletters, and other similar tools that transform the fleeting nature of a talk or demonstration to an everlasting teachable moment available for future generations.
   f. Intra-country, cross-discipline collaborations: COCONet data serves multiple purposes, serving not only solid earth and atmospheric scientists, but other communities, as well. Surveyors, engineers, social scientists, and other disciplines are increasingly taking advantage of geodetic data. Many more disciplines are expected to

use the data as new uses for the data are discovered. Open data policy drives new research and applications.

2. Funding: As in many countries worldwide, research funding in the Caribbean and Central America is weak and under-developed. Therefore, this situation hinders the ability to advance scientific discovery. Results from the pre-workshop survey show that there is a very limited number of potential funding agencies. The fact that opportunities exist, such as the NSF and USAID PEER program, and those available from the European Community, provide good opportunities to establish collaborations with universities, research institutions, and government agencies from United States, European countries, and Japan.

3. Products: Participants at the 3rd workshop expressed that the community is interested in a wide range of research projects using COCONet data. Among those projects is the need to perform the following:
   a. Earthquake source studies to identify and characterize active faults for the realization or update of seismic, volcano, and tsunami hazard mitigation maps.
   b. Assessment of urban geological hazards, such as:
      i. Estimating the location, magnitude and rate of subsidence and its implication on flooding susceptibility.
      ii. Critical infrastructure stability such as levees, bridges, dams, etc.
      iii. Landslide monitoring and mitigation. Countries in tropical regions have high rainfall and weathering rates. These factors when combined to large populations living in landslide prone areas become a major risk.
      iv. Effects of hydrocarbon and groundwater extraction.
      v. Caribbean Reference Frame realizations. SIRGAS, the Sistema de Referencia Geocéntrico para las Américas (Geocentric Reference System for the Americas) produce reference frames for the Caribbean region. However, it was brought to the attention of the community that stations being used for the computation do not fit the qualifications for geodynamic processes (*i.e.* many reference sites are installed on tall buildings, use weak or otherwise non-geodetic quality monuments, and suffer from the lack of appropriate metadata). COCONet sites have homogeneous equipment, monuments, which are designed to be well anchored to the ground, thus providing better data for the computation of the frame.

Furthermore, in order to take advantage of COCONet as a federated network of networks, in which newly installed or upgraded COCONet stations serve as a reference backbone for other smaller/local networks, additional effort is needed. In particular, the COCONet steering committee must be mindful that each country possesses unique and specific needs, which should be identified first in order to address them within the overarching scope of the COCONet project.

3.3.2 Network Sustainability

A topic that generates a sense of insecurity is the fate of COCONet after the initial funding of the project comes to an end in 2015. The issue of long-term equipment management was raised on several occasions during the discussion sessions. Some community members were concerned about the possibility of COCONet stations being short-lived; if local collaborating agencies are

unable to maintain newly installed and upgraded stations appropriately, there is a fear that this will result in off-line stations. In addition, equipment replacement is possible, if prices are reasonable and are affordable to local collaborating agencies. Special pricing offers or windows from manufacturers are seldom applicable to countries other than the USA, making it virtually impossible to obtain geodetic-grade GNSS instruments at reduced prices. One suggestion to circumvent this problem is for all COCONet collaborating institutions and agencies to become UNAVCO Associate Members, but that status does not always translate into eligibility for reduced pricing for GNSS instruments because of specific international policies with the vendors.

Several issues involving technical skills were also raised. Workshop participants urged that the training staff at local collaborating agencies should be offered regularly and guaranteed to ensure proper maintenance of the stations, data, and metadata. For example, the technical and specialized skills deemed to be most needed and appropriate are on site training and technical support. This could be achieved either by a visiting technician and/or researcher, or through a regional rotating technician, the development of how-to guides, and other digital publications. In addition, there was concern that the COCONet community required continuity of expertise in order to maintain and enhance the education of younger generations, which is critical to keep COCONet operations and scientific discovery based on COCONet data moving forward a steady pace through the project lifetime and beyond.

Workshop participants recognized that funding to guarantee healthy operation and maintenance of COCONet depends on its scientific achievements and long-term societal benefit. Therefore, ensuring that high quality research is carried out, good science is done, publications flow out, and that education & outreach efforts are met will undoubtedly justify COCONet's existence and help drive the network towards becoming self-sustaining.

Local governments and industry play an important role and may be critical in ensuring maintenance of sites; however, all stakeholders must be properly engaged by identifying the benefits that may emerge from their investment. In this sense, becoming a multi-national group provides leverage for individual countries throughout the COCONet footprint to fulfill their objectives, which may be individually identified as a need.

3.3.3 Data Formats, Flow, Processing and Products

All issues related to COCONet data and data products were discussed on the *Data* break-out session. This section summarizes those issues that concern the availability and usage of the data.

1. Format: In order for new stations be useful to both UNAVCO, the US scientific community it supports, and the local community, agreed upon data formats and rates should be established. The UNAVCO standard format is BINEX for both real-time streaming, while RINEX is the standard for archived data files. The surveying community in local countries are generally more familiar with to the standard international format of RTCM 2.X/3.X for real-time applications; otherwise, native receiver binary formats or their appropriate RINEX conversions are used. The alternative is to provide data in a number of formats, but a specific proceedures and protocols must be in place for this to be successfully implemented at UNAVCO and at Regional Data Centers.

2. Flow: Local users want to be able to set robust and efficient methods to obtain the data from the field. Learning how to fetch data files and archive them, as well as setting up NTRIP software for making available real-time data to the public in both BINEX for UNAVCO data users and RTCM formats for surveyors, engineers, and other civil works users was deemed critical. To this end, the community wants to have the proper training to install and configure the appropriate software, as well as having additional support in case problems arise.
3. Processing: Similar to the research discussion, having access to the data translates to the ability to process the data according to the needs of specific applications and institutional mandates. Therefore, providing training, education and capacity building is a critical factor for local scientific development, and potential data products available through a Regional Data Center.
4. Products: Among the data products the community is interested in providing or having access to includes: daily position estimates and position time series; rapid and ultra-rapid solutions for the estimation of earthquake parameters; co-seismic offsets for rapid tsunami warnings; community-defined plate boundary locations and Euler poles for estimating linear velocities between plates and blocks. In addition, additional contributions to risk assessment providing hazard and vulnerability studies, such as hazard mapping, fault definition and recognition and assessments, fault coupling maps and volcano deformation monitoring. Lastly, a realization of dedicated reference frame for the Caribbean to support these science and hazard mitigation goals was deemed to be of the highest priority for COCONet.

3.3.4 Regional Data Center

Representatives from several different institutions expressed strong interest in the possibility of hosting a Regional Data Center (RDC) as part of COCONet. Dr. Charles Meertens, UNAVCO Director of Geodetic Data Services, provided a detailed description of three scenarios for RDC's starting from the duties and requirements of a small center and scaling up to larger ones providing dedicated data services. Dr. Meetens' presentation and the ensuing discussion provided valuable information for the COCONet 3rd workshop participants to decide whether their institutions would be able to provide the appropriate data services and therefore compete to become a COCONet RDC. According to the pre-workshop survey, 11 out of 18 respondents showed interest in hosting a RDC. Whether the region will host a large data center or multiple smaller ones, or if they would be several data-specific centers (*i.e.* geodetic/ atmospheric / tide gauge) is unknown at this time. It is critical, however, to learn the ability of prospective host institutions to fulfill the requirements and absorb the duties of providing the data in an efficient and timely manner. Independent of the final number of RDC' s in the COCONet footprint, or the data products offered, all COCONet data must flow to the UNAVCO archive, as mandated by NSF. At the time of this report, all COCONet data is being incorporated into the PBO data analysis and processing stream.

The participants of the 3rd workshop felt that a significant step towards the establishment of an RDC is essential for the development of a sense of ownership of the data for the COCOnet community. It is critical, therefore, that UNAVCO develops within a short time frame (~6 months) a basic to medium (100+ sites) seamless "Data Center in a box" and other UNAVCO tools, which should be open and extensible to empower RDC's.

Among the different uncertainties for the requirements to operate an RDC were the quantity of technical personnel and their required skills, the required hardware and software, and the potential role of RedCLARA and C@ribNET for data transmission. It was suggested that potential RDC's develop a roadmap towards RDC requirement compliance (personnel, financial, technological infrastructure) and carry out connectivity tests to demonstrate feasibility before applying formally to UNAVCO to be a RDC. Once a potential RDC host is identified, UNAVCO could provide a start-up package containing both hardware and software, the so called "Data Center in the box," which is easily installed and configured for immediate operation, thus reducing maintenance and keeping local personnel to a minimum to run the RDC.

Among the proposed candidates for an RDC in the Caribbean region are the Puerto Rico Seismic Network (PRSN), the Seismic Research Center from the University of the West Indies (SRC-UWI), the Caribbean Institute for Meteorology and Hydrology (CIMH) in Barbados, the Colombian Geological Survey (CGS), the Costa Rica Volcanological and Seismological Observatory (OVSICORI), Universidad Simón Bolivar in Venezuela and the Institute for Geophysics at the Universidad Nacional Autónoma de México (UNAM) - as an observer and liaison to TLALOCNet – a planned 100+ network of new and enhanced cGPS and metpack network throughout Mexico.

The flow of data and availability was also a topic of significant interest and lively discussion. These discussions include evaluating whether alternative RDC transmission schemes should be implemented beyond the typical centralized method currently envisioned for COCONet. Proposed ideas included XML web services to provide alternative ways to transmit data, peer-to-peer protocols such as BitTorrent for data load distribution across multiple servers, and data mirrors.

The feasibility of a RDC in some of the represented countries is dependent upon the availability of international, state or local government funds. A possible way to cover the expenses of operations and maintenance could be through a NSF-PEER program grant. However, eligibility must be explored further because these programs tend to be driven by country-specific disaster and mitigation needs.

High-speed networks in the region such as RedCLARA and C@ribNet and the Caribbean Knowledge and Learning Network may play an important role in the telecommunications of the data among sites, RDC, and users. These networks, catering primarily to National Research and Education Networks (NREN), are being underused at present and plans to augment network speed and bandwidth are dependent upon the users and the overall network usage. RedCLARA and C@ribNet are inviting COCONet to take advantage of this resource to move data around without the bandwidth limitation. The COCONet community needs to create a liaison with representatives from these networks in order to generate action items to explore its feasibility.

3.4 Workshop Discussions for Atmospheric Science applications

3.4.1 Research opportunities

Understanding biases in atmospheric models is very important because there is high spatial and temporal variability in regional atmospheric data. Water vapor at hourly temporal resolution would be important for studying phenomena such as convective life cycles and mesoscale

organization of convection. Accordingly, it was proposed that the transition will be from precipitable water vapor (PWV) observations every thirty minutes to every five minutes. Power spectra of PWV retrievals shows that five-minute temporal resolution is closer to meeting the needs of the operational numerical weather prediction community. In addition, participants felt that there also needs to be a dialogue between those who create data and the needs of operational versus research community.

Another important question related to how data are transmitted. This could be done in a number of ways: for example, using the local data manager (LDM) protocol is the common approach adopted by much of the community (including researchers); whereas ingesting raw GPS data is the approach of many operational users.

One application of COCONet data would be for data assimilation, which is limited by computational resources. Another important application would be for real-time verification for weather forecasters. An example of non-real time use of the COCONet data would be for climate and weather model assessment.

Because COCONet GPS sites have power, a secure equipment box, and a communication system, if some information is already pre-processed (*i.e.* using a remote pre-processor), many users can more effectively use high frequency data. Currently, data is downloaded in one-hour increments. The atmospheric working group believed that adding five-minute meteorological data would not significantly impact overhead and urged UNAVCO and COCONet staff to move toward higher rate data downloads or data streams from as many sites as possible.

GPS-seismology would also require a high data rate (at least 1 Hz for some applications and as high as 5 Hz sampling for others) with latencies of less than a second. For real-time meteorology, the requirements would be well below what is needed for GPS-seismology applications.

Workshop participants suggested that UNAVCO and COCONet staff should investigate providing specific data products that would be useful to different user communities. Currently, the COCONet data protocols require that UNAVCO separate the data when it arrives at the archive in Boulder; 1 Hz GPS observations are used to estimate PWV over a thirty minutes interval. This protocol is useful for operational forecasting; however, there is use for even higher frequency data for areas such as operational forecasting and verification. Therefore surface meteorological data may prove extremely useful with five-minute or even one-minute frequency, although many participants were not sure yet what can be done with high frequency PWV observations. It was further suggested that one direct way to use data is to integrate the water vapor in a model and compare it to that obtained from a single GPS station to examine biases in the model. Currently, data assimilation of precipitable water vapor data remains a topic of active research, and thus COCONet data should be invaluable for assessing the value and utility of these data in numerical weather models.

3.4.1.2 Climate modeling

COCONet 3rd workshop participants explored the possibility that COCONet would only last for 5 years, as originally planned and funded. In that case, would COCONet data be useful to understand climate processes? The consensus answer was that in order to evaluate climatic processes, it was

necessary to double life of COCONet from 5 to 10 years, which should be useful for examine decadal variability and do meaningful climatic intercomparisons.

It was further suggested that perhaps the Caribbean atmospheric science community should pursue an intensive field campaign to study significant atmospheric processes/phenomena such as the Caribbean Low Level Jet (CLLJ) and the convective signal over Colombia. Small islands in the Caribbean could prove useful for examining CLLJ because most of the observations are around the periphry of the Caribbean Basin and not in the middle of the basin where the core of the CLLJ is located. The issue with intensive field operations, however, is competition with other programs.

The NSF traditionally has not supported long-term monitoring, yet many of the COCONet 3rd workshop participants felt that such data were essential to evaluate a wide range of climatic processes. It was further suggested that the next big Caribbean field campaign should coordinate with the COCONet atmospheric community to develop and submit a proposal.

Within the Caribbean basin, the use of water vapor data has wide scope, because regional operational centers have been identifying key processes, which are affected by water vapor variability. Many participants believed that if NSF sees a steady stream of proposals submitted to use COCONet data, the impetus to maintain COCONet would be self-evident.

Finally there was discussion on the feasibility of putting GPS on NBDC buoys. The NBDC buoys are large, robust and can handle GPS equipment mounted on the platforms. The question remains whether bandwidth and data transmission from the buoy be an issue; however, with technological enhancements and lower per bit data transmission costs, this may be facilitated in the near future.

3.4.2 Data Processing and Products

This session was moderated by Dr. John Braun of UCAR/COSMIC who started off by showing how to access and download data through Suominet at http://suominet.ucar.edu. Dr. Braun said that there are number of ways to get the data, including via the web, or the local data manager (LDM) protocol, and UCAR was working on making data available through GTS (mostly for operational centers). Workshop participants thought that too many methods to obtain data might not be beneficial to the COCONet atmospheric science community. It was suggested that it might be useful to have a description (for example, a small on-line tutorial) on how to obtain the data, what the data is, and how the data may be used for different applications (in both English and Spanish). If one has not attended the COCONet meetings one would be confused as to how to get the data.

In addition, it was further suggested to provide the user freedom to obtain only the observable that is needed, so that an individual user could select only the data of interest versus downloading all the data. The first step to improving this process would be better documentation on how to get the data. The data are available in various data formats (*e.g.* BUFR, NetCDF, and ASCII), which remains necessary because various sectors of the atmospheric community currently use different formats for ingest, assimilation, and analysis.

Many participants believed that an article written by the atmospheric group for submission to the Bulletin of the American Meteorological Society (BAMS), which would describe the current data protocols and products related to COCONet would be beneficial and should be explored. In addition, there was also a recommendation for UNAVCO and Suominet to link to a single COCONet

website, which would unite the geodetic and atmospheric community. While a COCONet website has been developed (http://coconet.unavco.org), this is could use additional functionality and increased focus on data products and their uses. It was felt that the current website is very confusing and could be improved for both the casual and power user alike. In particular, COCONet 3rd workshop participants believed that when one goes to the COCONet page, some description on how to get the data would be helpful.

There were other data access issues such as confusion about the processing time interval for atmospheric data products, which is important for the numerical weather and climate data assimilation communities. The thirty-minute cycle used to be 00 and 30 of each hour and has now been changed to 15 and 45 of each hour. Dr. Braun recommended that they would like to go back and re-process so that the time interval is consistent for all data products, suggesting that 00 and 30 past each hour is probably the better method for data assimilation purposes.

In terms of data formats, UCAR will continue producing BUFR, ASCII and NetCDF products because the various formats are needed by different subsets of the atmospheric community. However, one-minute data are useful for some users in the community. Surface meterological data would be very useful at high temporal resolution, including one-minute intervals. It was recommended that the high frequency data should be included in a different file. In addition, most workshop participants felt that having surface data co-located with the GPS-estimates of precipitable water vapor would be very useful to give a more complete picture of what is going on in the atmosphere.

Another issue is validation of the data. It was noted that it will be difficult to compare surface met data and PWV estimates from certain remote sites (for example, those on cays in the middle of the Caribbean Sea), because these sites are isolated and far removed from other stations such as those operated by various Met Services or other institutions, which makes evaluation of data from some COCONet remote stations difficult.

Carlos Fuller of the CARICOM Climate Change Centre (CCCCC) stated that they were in the process of procuring sixty meteorological and hydrometeorological stations as part of the Global Climate Change Alliance (GCCA) project, with data going directly to the regional meteorological services, and that these sites may be co-located with a COCONet GPS station with appropriate coordination with CCCCC. The surface met stations will have satellite telemetry, will be WMO stations (will have WMO identifiers), and further will be on the GTS.

Several participants inquired whether funding from developing countries, either alone or in partnership with the US or other contries, may be available to continue operating COCONet after the initial five year period is over. One possibility is that perhaps the WMO would be willing to facilitate ongoing O&M COCONet; although, there may be some issues with COCONet sites conforming to WMO standards.

The European Centre for Medium-Range Weather Forecasts (ECMWF) has an excellent data analysis center and has identified Central and South America as an area with deficient data coverage. It may be possible to approach ECMWF with a proposal to collaborate in order to get access to their analysis and do some type of formal "data exchange." The atmospheric working group encourages COCONet to explore the possibility to formally collaborate with ECMWF and therefore possibly get free access to their data for the COCONet atmospheric science community.

Finally there was a suggestion to install coral reef monitoring stations as an extension of COCONet. These sites would send the data directly back to University of Miami, to be used as supplement to the GPS and surface met observations from the COCONet network. The proposed coral reef monitoring stations are full meteorological stations on a buoy (probably only parameter not measured is rainfall). Data from these sites may exist at a few sites and may have time-series as long as five years in some cases; these data may be of significant use to interpret and extend the length of the COCONet time series.

SECTION 4: Recommendations

Based on the discussions at the COCONet 3rd workshop, and the evaluations from the organizing committee, the following recommendations are presented to UNAVCO and the COCONet community:

4.1 Capacity Building

1. Provide the necessary tools to the COCONet community for the wide range of activities. These include to keep providing short-courses on data processing such as those previously sponsored for GAMIT/GLOBK, Track/TrackRT, and (T)DEFNODE.
2. Provide training sessions or workshops for the installation and usage of important software:
    a. Data transmission (using scripts, NTRIP for real-time)
    b. Data processing (GAMIT/GLOBK, GIPSy/OASIS, Coulomb, and (T)DEFNODE, etc.)
    c. Data products (Rapid Moment Tensors from various methods including GPS+accelerometer methods using Kalman filters, and tsunami travel time estimates based on rapid estimation of earthquake parameters).
3. Work towards the establishment of a media library featuring on-line video tutorials ranging from instrument set-up to data processing and webinars of distinguished lecturers in a variety of UNAVCO-backed science topics.
4. Establish a listserver, a monthly newsletter, and either a forum or a blog for the COCONet community to exchange ideas and post questions as well as answers related to various aspects of the project.
5. Explore the feasibility of having a visiting rotating expert to address technical and scientific problems in the region. These can range from installation of software to the development and implementation of a targeted science research project.
6. Frequently update the COCONet website to feature newly installed sites, data availability, research highlights, and recent publications, photos, tutorials, and webinars.
7. Create a working group to take advantage of the upcoming summer 2013 PASI workshops by recording and/or webcasting the presentations. Provide these videos to the entire COCONet community through a newly established UNAVCO video/media library (see recommendation 3 above).

4.2 Sustainability

1. Encourage UNAVCO Associate Membership for countries hosting COCONet stations. The high cost of one-time membership fee may be a limitation for some countries, hence explore a reduced or waived membership fee for eligible countries.
2. Affiliation to UNAVCO does not guarantee that international members will be eligible for reduced instrument prices, hence it is recommended that all countries to unite as a COCONet regional group to ask individual instrument distributors to compete for group pricing.
3. Draw attention of the COCONet project to CARICOM and other regional political agencies/groups in order to build a profile and be eligible for operations and maintenance funds.
4. Create a working group to promote the science goals of COCONet and how countries in the region are united to learn more about potential geologic and atmospheric hazards.

4.3 Data

1. Develop and implement a protocol/mechanism to credit and acknowledge COCONet community contributions (for example, data center work or effort, contributed data sets, data products, and publications, etc.), and further to advertise how to acknowledge the use of COCONet data.
2. Define and list the names and locations of the 10 low-latency proposed sites streaming 1 Hz data in real-time. The community is confused whether the 10 sites have been identified already or if they will be assigned as they are installed.
3. Provide a COCONet map with the available power and data communication capabilities at every site. This would serve as an indicator of which sites have little or no power or communication limitations and thus may become real-time streaming sites above and beyond the originally envisioned 10 real-time sites.
4. Explore the feasibility of streaming 15-second sample rate data for all stations capable of handling this data rate. This strategy may prove simpler and cost-efficient than the current 1 Hz 30 or 60-minute data files, reduce latency, and further could allow a larger number of stations with higher rate real-time stream.

4.4 Regional Data Center

1. Work with the COCONet community to implement in the region either one large Regional Data Center or several small ones. In order for this to move forward, UNAVCO should present to interested host institutions: (1) A list of requirements to which each potential host institution should abide in order to comply and evaluate if they are apt to become an RDC; (2) A request for proposal in which potential host institutions present evidence of their qualifications and capabilities.
2. Creation of a working group to evaluate UNAVCO's RDC requirements, and applicability of potential RDC host candidates.
3. Creation of a working group to evaluate contributions of RedCLARA and C@ribNet, and how these can be incorporated to COCONet through the National Research and Education Networks.

4.5 Stations

1. A station in Cayo Serranilla, a Colombian cay located southwest of Jamaica, was installed by the Colombian Geological Survey more than two years ago. The station currently does not have remote data access. Funds permitting, UNAVCO staff are encouraged to install telecommunications and a meteorological instrument to allow real-time or near-real-time data access. This station is a key site because of its close proximity to the central Caribbean plate region.

SECTION 5: Brief Summary of Pre-workshop Survey

5.1 Relevant Results

1. Roughly 1/3 of participants attended the previous two COCONet workshops, so the base of attendees have been refined over the three workshops and the community of operators is now well established.
2. The community supported, at a ratio of roughly 2:1, the option of additional stations and training rather than spending remaining funds on the upgrade of sites for redundant telecoms, barometer/infrasound microphone or additional meteorological instruments. In other words, the community feels that the network would be stronger if we densify as much as possible, therefore increasing the number of sites, and also use additional resources to enhance training.
3. The respondents gave the strongest grade (best rating) to the installation, management and equipment, and the lowest grade (worst rating), yet the highest desire for improvements in data products, data flow and education and outreach issues.
4. Those questions that require additional comments show a wide range of comments and almost no overlap. One possible explanation is that the community is still not fully using COCONet data, thus have not fully formulated specific issues that should be addressed beyond the already overall issues discussed above.

5.2 Pre-workshop Survey Conclusions

Most grades are in the good (but not in the excellent) grade, meaning that even though the performance is more than acceptable, the respondents believe that there is still some room for improvement in all areas of the COCONet project.

The high desire for additional training and education will in part be addressed with the upcoming PASI workshops. The COCONet steering committee, PASI organizers, and UNAVCO all need to assure that these training courses are well attended and extend their reach by webcasting and online videos/training materials. They also need to be very well advertised.

Low grades for data products and data flow should be addressed by:

- Expanding/redesigning the COCONet website, including tutorials and a better description of data access and analysis procedures in several languages; and
- The development and implementation of a plan for Regional Data Centers.

Many of the issues receiving the lowest grades from the respondents have specific actions already in the planning stages (except one), so there is no immediate need for radical actions in this regard. The remaining issue still not fully developed is technical training for personnel who will be servicing the COCONet sites. While additional scientific training will be available at the two upcoming PASI courses, basic technical training for local field staff should also be strongly considered. The most obvious path would be to open a field maintenance training program at UNAVCO, where local COCONet operators could team up with Geodetic Infrastructure field and

participate in PBO site visits to obtain a few weeks of hands-on training.

SECTION 6: COCONet Future Plans

6.1 Formation of a Regional Data Center

Based on the recommendations set on Section 4.4 above, one or more RDCs are expected to be implemented in the Circum-Caribbean region to provide COCONet data, products, and services to local, regional and global users. In the following months, UNAVCO will provide a list of requirements necessary for a host institution become a RDC, along with a request for proposals. UNAVCO staff, in close consultation with the COCONet Working Group and cognizant NSF program officers, will make the final selection of the one or more RDCs; through this open process, we anticipate that any institution within the COCONet footprint could be selected as a RDC, if it meets the required criteria, and therefore all interested institutions are encouraged to apply. Interested institutions should submit a proposal specifying the qualifications, capabilities, and interest in becoming a RDC. Upon proposal evaluation, UNAVCO may sponsor a site visit for potential candidates and to further discuss with the candidate institutional representatives the steps towards the implementation of a RDC. UNAVCO may sponsor one or two of these RDC's for one year until project completion in FY2015, at which time the host institution should become self-sustainable or apply for funds to continue operations. The initial contribution from UNAVCO may be in the form of hardware, software and support. More than two RDC's may co-exist in the region and is encouraged, however, these must be self-supported. A RDC is expected to provide both data in real-time and data files (daily and hourly) in BINEX format either by a NTRIP caster and/or an FTP server.

6.2 Collaborations with RedCLARA and C@ribNet

In May 2012, the Caribbean Knowledge and Learning Network (CKLN) implemented a high capacity broadband research and education network called C@ribNET in OECS - the Eastern Caribbean States, which are members of Caribbean Community (CARICOM). Since C@ribNET provides connectivity to national colleges and the Open Campus of the University of the West Indies (UWI) in each OECS Member State, COCONet partner - the Seismic Research Centre of the UWI immediately recognized the potential benefits that the COCONet project could derive from the network. C@ribNet is also connected to RedCLARA, a similar research and education network in Latin America with several participating states in the COCONet footprint; both networks are further connected to the world's research and education community through AMPATH to North America, through GÉANT2 to Europe.

In an effort to learn more about C@ribNET and RedCLARA, in particular, how both networks could be leveraged to serve the needs of COCONet, representatives of both were invited to address the gathering of the COCONet 3rd workshop in Tulum, Mexico. Ms. Colleen Wint-Smith, Communications & International Relations Manager of CKLN and Mr. Jesús Cruz from CUDI, the Mexican National and Research Network (NREN) gave presentations on C@ribNET and RedCLARA, respectively.

C@ribNet was established to bridge the digital divide in the Caribbean that inhibited interconnectivity between the regions colleges, universities, hospitals, regional and national public institutions as well as to other global education and research networks. The C@ribNet project was initially funded in December 2007 through a financing agreement between the EU and CARICOM that made a grant of €10M available to CKLN, the executing agency. The primary backbone of

C@ribNet is a fiber ring with nodes in Miami, The Dominican Republic, Jamaica and Trinidad. Miami is the gateway to INTERNET2 via AMPATH. All Eastern Caribbean territories except Barbados are served with connections to the Jamaica node via Grenada. Barbados is linked into the Dominican Republic node, which also links C@ribNet to GÉANT2 via Paris. Jamaica links C@ribNet to RedCLARA via Panama.

A key objective of CKLN is to ensure the global competitiveness of the Caribbean labor force by facilitating the use of ICTs in the delivery of tertiary education (*i.e.* college and university level). To this end, certain priority applications will be hosted on the network. These may includes e-Learning platform for collaboration in course and program development, a portal for student administration for Caribbean TLIs, Commodity Internet access, multiparty HD video conferencing, and online security tools.

RedCLARA is an advanced network infrastructure that interconnects the National Research and Education Networks (NRENs) of Latin America. It also provides inter-regional connectivity to Europe through the pan-European advanced network GÉANT2 at 622 Mbps via a link between Sao Paulo (Brazil) and Madrid (Spain) and to the US through links established between Tijuana (Mexico) and San Diego (USA Pacific Coast) and between Sao Paulo and Miami (USA Atlantic Coast). The connectivity to the USA has been established through the (WHREN/LILA) project with funding from the National Science Foundation. The Western Hemisphere Research and Networking (WHREN) is a cooperative initiative of research and education networks across the Americas with a community based cyber-infrastructure that fosters a forum for Pan American collaboration. WHREN serves as a coordinating body whose aim is to leverage participants' network resources to foster collaborative research and advance education throughout the Western Hemisphere. The U.S. NSF partially supports WHREN through funding of Links Interconnecting Latin America (LILA). The Academic Network of Sao Paolo (ANSP), the Corporation for Education Network Initiatives in California (CENIC) and Florida International University (FIU), provide the remaining funds.

The backbone of RedCLARA consists of ten main routing nodes connected in a point-to-point topology. Each main node characterizes a PoP (Point of Presence) for RedCLARA. Five of the main routing nodes are located within the COCONet footprint, namely Bogota (BOG - Colombia), Panama (PTY - Panama), San Salvador (SSV - El Salvador), Tijuana (TIJ - Mexico) and Miami (MIA - United States). Colombia (RENATA), El Salvador (RAICES), Panama (RedCYT), Guatemala (RAGIE), Mexico (CUDI), Venezuela (REACCIUN2) and Costa Rica. These are all COCONET participating countries that are already connected via respective NRENS (in brackets above). There are future plans to connect Cuba, Honduras and Nicaragua. Infrastructural capacity building is ongoing between the Latin American nodes.

With several universities and research centers now connected to RedCLARA, many projects, which require modern ICT infrastructure to support communication and collaboration, are now able to advance, for example, distributed computing, data manipulation, visualization, remote instrument/experiment control and other scholastic applications and services. In Mexico, the CUDI network is currently used to network seismic strong-motion instrumentation.

Both C@ribNet and RedCLARA are designed with advanced e-infracture to support formal entities that use advanced networking technology and services for research and education, knowledge

transfer as well as international cooperation. With several points of presence in the COCONet footprint these networks are ready to support services from basic inter-networking to build up the cGPS infrastructure to more resource demanding applications such as distant training via web and video conferencing. As an entity that has fostered an alliance amongst regional stakeholders with interest in geodesy, COCONet is positioned to federate the interests of large communities of practice. Through such stakeholder alliance and collaboration with RedCLARA and CKLN, there will be greater opportunities to share common applications and practices and share the costs of international connections and long-term development in the geographical space. A working group has been established to investigate and establish collaborations with RedCLARA and CKLN. Other specific tasks that could make effective use of this cyber-infrastructure has been also identified and will be pursued.

6.2.1 COCONet Working groups

In order to build capacity and transform COCONet into a more sustainable entity, participants in the 3rd Workshop believed that it would be necessary to accelerate project in some key strategic areas and that this could be carried out by volunteer working groups over the course of year 3 of the project. Four strategic areas, which could develop working groups, were identified during 3rd workshop. The following is a summary of these four working groups, along with their strategic objectives, task outlines and a list of volunteers willing to participate.

COCONet Working group 1 – Data Networks

Strategic Objective: Investigate and test the feasibility of leveraging CKLN/RedCLARA networks for end-to-end GPS data transport and receiver control.

A proposed guideline for achieving this objective follows:

- Determine CKLN /RedCLARA access and connectivity requirements.
- Determine where the CKLN/RedCLARA access nodes are located in the COCONet footprint in relationship to the installed or planned cGPS stations and repositories.
- Determine feasibility of using such locations as CORS site and/or last-mile communications requirements to nearest CORS.
- Determine communications requirements to repositories and or Data Centers.
- Procure last-mile medium and conduct end-end test in 4 pilot regions.
- Prepare test and feasibility reports for Network Administration.

For this workgroup the members were drawn from a few pilot states/regions, UNAVCO, RedCLARA and CKLN. The suggested timeframe for execution is end of March 2013.

The proposed members of Working group 1 and their affiliations are:

- Enrique Cabral (Mexico/N. America)
- Marino Protti (Costa Rica/C. America)
- Hector Mora (Colombia/S. America)
- Lloyd Lynch (Trinidad/SE Caribbean)
- Chuck Meertens (UNAVCO)
- Rep. from CKLN (To be identified)
- Rep. from RedCLARA (To be identified)

COCONet Working group 2 – Regional Data Centers

Strategic Objective: Determine the Data Processing/Data Center (DP/DC) requirements of COCONet member regions.

A proposed guideline for achieving this objective follows:

- For each of 4/5 institutions expressing interest from pilot sub-regions:-
  - Determine current and future community needs (national, sub-regional and regional).
  - Determine current DP/DC resources in these regions and estimate resource needs/requirements to scale such requirements to meet community needs.
  - Develop a scaling strategy and an attendant proposal
- Evaluate all proposals with a view to identify synergy and other resource saving opportunities.
- Based on feasibility, make appropriate recommendations on meeting objective.
- Develop regional strategy and proposals to secure the necessary resources.
- Report findings

The proposed members of Working group 2 and their affiliations are:

- Hector Mora-Páez (CGS, Colombia/S. America)
- Machel Higgins (SRC-UWI, Trinidad/E. Caribbean)
- Alberto López (UPRM, Puerto Rico/N. Caribbean)
- Enrique Cabral (IG-UNAM, Mexico/N. America)
- Dave Mencin (UNAVCO/ USA)
- Representatives from RedCLARA and CKLN (To be identified)
- Representative from INETER/Nicaragua (To be identified)

COCONet Working group 3 – Scientific Training

Strategic Objective: Develop plans for having the three 2013 COCONet PASI's videocasted and webcasted to selected institutions within COCONet member regions.

A suggested guideline for achieving this objective follows:

- Work with PASI organizers to determine requirements for recording at and for transmitting live video and web feeds from the course venues.
- Determine the number of candidates who wish to participate in courses remotely and identify appropriate sub-regional institutions to host the broadcasts.
- Determine cost and other requirements.
- Secure resources to make it happen and make the necessary preparations.
- Report to COCONet Community before May 2013

The proposed members of Working group 3 and their affiliations are:

- Andrea Sealy (CIMH-UWI, Barbados/ Caribbean)
- Rob Watts (SRC-UWI, Trinidad/E. Caribbean)
- John Braun (UCAR, Colorado/USA)
- Pete LaFemina (PSU, Pennsylvania/USA
- Representative from RedCLARA and CKLN

COCONet Working group 4 – Community Engagement and Outreach

Strategic Objective: To promote COCONet in other scientific and non-scientific communities within the COCONet footprint region. By targeting the follow communities, more interdisciplinary collaboration could be forged, thereby giving the COCONet project more traction and longevity. Since there are other regional programs and projects running in parallel with COCONet this initiative could identify prospects for resource sharing and other benefits.

- Scientific: Geological, Seismological, Hydrological, Meteorological, Volcanological, and Tsunami EWS
- Non-Scientific: Surveying, Agricultural, Environmental , Civil Engineering and Mining

Possible media that may be used include:

- Conferences: e.g. Caribbean Geological Conference, CDM Conference, AGU
- Outreach Activities
- Newsletter articles
- Weblinks to COCONet
- Determine the avenues that could be leveraged to promote COCONet

A suggested guideline for achieving this objective follows:

- Prepare current articles/presentation on COCONet
- Seek opportunities to publish/present COCONet activities through avenues/media identified
- Find individual(s) from COCONet community to deliver
- Evaluate and Document

The proposed members of Working group 4 and their affiliations are:

- Carlos Fuller (CCCCC - Climate Change, Caribbean)
- Hector Mora-Páez (CGS – Geodynamics, Columbia)
- Leslie Jasen Hodge (Government – Surveying, Caribbean)
- Alberto López (UPRM – Seismology, Puerto Rico)
- Frank Audemard (FUNVISIS – Geology and Tectonics, Venezuela)
  CIMH representative (CIMH - Hydro-meteorology, Caribbean)

6.3 Installation of remaining sites

At the time of this workshop report, UNAVCO has two full-time COCONet field engineers: John Sandru, who was hired in late summer 2012, and Michael Fend, who was hired in early February 2013. Jim Normandeau is now doing much of the COCONet Project Management, which includes the oversight of all field engineering efforts related to COCONet. For year 2013 the installation of new sites, upgrades to collaborators sites and repair or hardening of existing COCONet stations are listed below in no particular order. A total of 16 new site installations, 12 site upgrades, and communications infrastructure improvements are planned. The timing of specific activities will depend on coordination with COCONet partners, weather, and other logistical constraints. Note that the four character site designations refer to the siting plan as reviewed and approved at the 2nd COCONet workshop in Trinidad, with modification by the COCONet siting and oversight committee (now the COCONet working group).

(1) Dominican Republic

- (a) Upgrade of the 4 JI sites
  - (i) Install Trimble NetR9 receivers with choke rings
  - (ii) Install Vaisala metrological instruments
- (b) Upgrade the 5 existing sites with choke ring antennas
- (c) Fix/reconfigure communications infrastructure for 2 existing sites: CN06 and CN07

(2) Virgin Gorda

- (a) Installation of 1 new site: CN03

(3) Bahamas

- (a) Installation of 2 new sites: CN13 and CN14
- (b) Overhaul of CN15 – hardening of site, new enclosure and hardware

(4) Anguilla

- (a) Installation of 1 new site: CN02

(5) Honduras

- (a) Installation of 2 new sites: CN18 and CN21
- (b) Upgrade of ROA0 – receiver, antenna, equipment enclosure

(6) Panama

- (a) Installation of 2 new sites: CN28 and CN34

(7) Jamaica

- (a) Hardening of sites: CN10 and CN11

(8) Venezuela

- (a) Reconnaissance of existing sites
- (b) Installation of 4 new sites: CN41, CN42, CN43, and CN44

(9) Trinidad and Tobago

- (a) Installation of 1 new site: CN45
- (b) Upgrades of 2 existing sites: FORT and GALE

(10) Cuba

- (a) Installation of 1 new site: CN16

(11) Antigua

- (a) Installation of 1 new site: CN01

(12) St. Lucia

- (a) Installation of 1 new site: CN47

(13) Nicaragua

- (a) Fix/reconfigure communications infrastructure for 3 existing sites: CN22, CN29, and CN30

Appendix A: Workshop Agenda

Tuesday, October 23, 2012

Scheduled Activities: 4:00pm - 7:30pm Registration and Poster Set up
6:00pm - 7:30pm Ice Breaker Reception
7:30pm Dinner on own

Wednesday, October 24, 2012

7:00 - 8:00	Breakfast: On own in World Cafe and registration	
8:00 - 8:05	Welcome message from UNAVCO President	M. Miller, UNAVCO
8:05 - 8:10	Welcome by Organizing Committee Chair	A. López, UPRM
8:10 - 8:25	Update on station installations	K. Feaux, UNAVCO
SESSION I Project Evaluations: Accomplishments and path forward		
8:25 - 9:05	Open discussion: Towards COCONet goals: Roadmap and road travelled so far	L. Lynch, UWI
9:05 - 9:35	Open discussion: Looking to the future: Where are we and where are we going?	E. Cabral, UNAM
9:35 - 9:45	Siting challenges	K. Feaux, UNAVCO
9:45 - 10:15	Break - Convention Center Foyer	
SESSION II Data		
10:15 - 10:30	Data Flow Requirements: From site to regional data center	J. Normandeau, UNAVCO
10:30 - 11:00	The NGS Data Archival system, QC and availability	G. Sella, NGS
11:00 - 12:00	Seismo-tectonics and volcanic processes in the Lesser Antilles: GPS Data production of IPGP Observatories	JB. de Chabalier, IPGP
12:00 - 12:30	Novel methods in GPS data processing: Merging co-located high frequency GPS, accelerometer, and meteorological data at GPS stations	D. Melgar, UCSD
12:30 - 2:00	Lunch - On own - various restaurants	
SESSION III Research		
2:00 - 2:30	Recent GPS studies of the NE Caribbean and tomography of the caribbean region	U. ten Brink, USGS
2:30 - 3:00	High resolution NWP and Data assimilation	S. Chen, RSMAS
3:00 - 3:30	Deformation of the Western Caribbean from GPS geodesy	P. LaFemina, PSU
3:30 - 3:45	Break - Convention Center Foyer	
3:45 - 4:00	Current Atmospheric research facilitated by COCONet Data	A. Sealy, CIMH
4:00 - 4:40	The Mw7.6 September 5, Nicoya Peninsula Earthquake special session	M. Protti, OVSICORI

4:40 - 6:00 Research Opportunities
Breakout Session I: Atmospheric Sciences (Chichen Itza II) D. Enfield, UM-CIMAS
Breakout Session II: Solid Earth (Chincen Itza I) P. LaFemina, PSU
6:00 - 6:30 Re-convene for breakout session summary Chichen Itza I
6:30 - 7:30 Posters session* and reception Convention Center Foyer
7:30 Dinner -On own Various Restaurants

Wednesday, October 25, 2012

7:00 - 7:40 Breakfast: - On own in World Cafe
7:40 - 8:00 Caribbean Tide-gauge network status (From Session I on the 1st Day) D. Simons, ABMS

SESSION VI COCONet Sustainability and Capacity Building
8:00 - 8:30 USAID Invited Talk - via telecon G. Mayberry, USAID
8:30 - 8:50 National Science Foundation - Invited Talk R. Kelz, NSF
8:50 - 9:00 PASI and MoA announcements
9:00 - 9:25 Regional Research and Education Networks: The Caribbean Knowledge and Learning Network (CKLN) C. Wint-Smith, CKLN
9:25 - 9:40 Creating synergies among communities & network operations L. Lynch, SRC
9:40 - 10:00 Solving instrumentation problems & difficulties H. Mora, CGS
10:00 - 10:15 Break - Convention Center Foyer
10:15 - 11:30 Breakout Session III:
Funding opportunities & plans for keeping COCONet Alive G. Mattioli, UNAVCO
Breakout Session VI: Network maintenance plans: Managing to keep the network alive E. Cabral, UNAM
11:30 - 12:00 Re-convene for breakout session summary Chichen Itza I
12:00 - 12:50 Lunch On own - various restaurants
12:50 - 1:00 Group Photo

1:00 - 1:30 The use of GPS Meteorological Networks for studying deep D. Adams, UNAM

SESSION II Continued from day I Data Flow Requirements: From site to Regional Data Center
1:30 - 2:40 Breakout Session V: Data processing & products for the Atmospheric Sciences J. Braun, UCAR
Breakout Session VI: Data processing & products for Solid Earth M. Protti, OVSICORI
3:00 - 6:00 Field trip to Tulum Mayan Ruins** with TLS demonstration or free time
6:00 - 7:00 Posters session* and reception Convention Center Foyer
7:00 Dinner - On own Various Restaurants

Friday, October 26, 2012

7:00 - 8:00	Breakfast - On own in World Cafe	
SESSION V Regional Data Center		
8:00 - 8:30	The SCIGN example	J. Galetzka, CTO
8:30 - 9:00	The PBO example	C. Meertens, UNAVCO
9:00 - 9:20	The Caribbean Institute for Meteorology and Hydrology A. Sealy, CIMH	
9:20 - 10:00	Presentations on proposed RDC's in the Caribbean: Capabilities & Facilities of potential organizations in the Region The Puerto Rico Seismic Network The Seismic Research Center (UWI)	
10:00 - 10:15	Break Convention Center Foyer	
10:15 - 11:30	Breakout Session VII: Requirements for Data Flow and Archival	A. López, UPRM
	Breakout Session VIII: Requirements and Procedures for the establishment of a Regional Data Center	G. Wang, UH
11:30 - 12:00	Re-convene for breakout session summary	Chichen Itza I
12:00 - 12:20	Final remarks and closure -	Meeting Adjourned All
12:20 - 2:00	Lunch and departures	On own - various restaurants

**Posters are open but not limited to:*
-Research (projects, ideas, opportunities),
-Data (Data Centers, archival, products, availability),
-CGPS Networks in the Caribbean (per country/ institution/ agency),
-What each country / institution/ agency plans on using data (what are their plans?), etc…
*** Field trip departs hotel at 3:00 pm and arrives at 5:15 pm and requires a payment of $29 per person to cover entrance fee to the park and transportation to and from hotel*

Appendix B: Workshop Participants

Antonio Abrego
Panamá Canal Authority
Panamá, 0819-00007
507 276-1989
aabrego@pancanal.com

David Adams
Universidad Nacional Autónoma de México
Centro de Ciencias de la Atmosfera
Circuito Investigación
Ciudad Universitaria
Mexico, DF 04510 México
52 (55) 57663717
dave.k.adams@gmail.com

Franck Audemard M.
Venezuelan Foundation for Seismological Research -FUNVISIS
Final Prolongacion Calle Mara, Quinta FUNVISIS, El Llanito
Caracas, Miranda 1073 Venezuela
+58-212-2575153
faudemard@funvisis.gob.ve

John Braun
UCAR/COSMIC
P. O. Box 3000, UCB 429
Boulder, CO 80307 USA
303-497-8018
braunj@ucar.edu

Mizael Bravo
Simon Bolivar University
GPS Lab, Dpt. Earth Sciences, edif. FE II, Of. 315
Baruta, Caracas, Miranda 1080A Venezuela
0058-426-4101763
07-40672@usb.ve

Lyndon Brown
Earthquake Unit,
University of the West Indies, Mona
Kingston 7
Jamaica
(876) 9272586
lyndon.brown@uwimona.edu.jm

Toby Burrough
University of Houston
2701 W Bellfort Apt 1401
Houston, TX 77054 USA
713-870-4175
tmburrough@yahoo.com

Enrique Cabral-Cano
Universidad Nacional Autónoma de México
Instituto de Geofísica
Circuito Investigación
México, DF 04510 México
52 (55) 5622-4204
ecabral@geofísica.unam.mx

Giancarlo Canales
Universidad del Sagrado Corazón
URB PUERTO NUEVO
SAN JUAN, PUERTO RICO 00921 PUERTO RICO
+17876678775
gcanalesb@me.com

Esteban Chaves
OVSICORI
la Sabana, San José 0032-1000 Costa Rica
(506)87054037
echfisica@gmail.com

Shuyi Chen
RSMAS/University of Miami
Miami, FL 33149 USA
305-421-4048
schen@rsmas.miami.edu

Kathleen Compton
University of Arizona
1040 E 4th Street
Tucson, AZ 85721 USA
206-321-1701
kcompton@email.arizona.edu

Peter Dare
University of New Brunswick
Dept of Geodesy and Geomatics Engineering
PO Box 4400
Fredericton, New Brunswick E3B 5A3 Canada
+1-506-447 3016
dare@unb.ca

Jean-Bernard de Chabalier
IPGP - Guadeloupe Observatory
Gourbeyre, French West Indies 97113
Guadeloupe
+590 590 99 11 38
dechabal@ipgp.fr

Juan De Jesús
Universidad Nacional Autónoma México
6to Cjon de las Flores #8; Colonia Los Reyes
Delegación Coyoacán
D.F., México 04330 México
(5255) 1517-8062
payero@ollin.igeofcu.unam.mx

David Enfield
University of Miami/CIMAS
4301 Rickenbacker Causeway
Miami, FL 33149 USA
305-361-4351
david.enfield@noaa.gov

Luis Eveline
Universidad Politecnica de Ingenieria, UPI
Residencial La Granja, Calle Principal
Comayaguela, Tegucigalpa MDC, FM 11101
Honduras
(504) 2225-2991
leveline@yahoo.com

Karl Feaux
UNAVCO
6350 Nautilus Dr
Boulder, CO 80301 USA
303-381-7556
feaux@unavco.org

Jose Luis Fernandez
Oficina Nacional de Meteorología (ONAMET)
Calle odfelismo #51, Ensanche Ozama
Santo Domingo Este, Santo Domingo 11501
Republica Dominicana
8097963963
josenet2004@yahoo.com

Carlos Figueroa
Instituto Geográfico Nacional
San Salvador, San Salvador 0101 El Salvador
503-78716162
c!gueroa@cnr.gob.sv

Carlos Fuller
Caribbean Community Climate Change Centre
Lawrence Nicholas Building, PO Box 563, Ring Road
Belmopan, Cayo District 99999 Belize
5018221104
cfuller@btl.net

John Galetzka
Caltech Tectonics Observatory
1200 E. California Blvd, MS 100-23
Pasadena, CA 91125 USA
6263744153
galetzka@mac.com

Warren Gallaher
UNAVCO
6350 Nautilus Drive
Boulder, CO 80301 USA
303-381-7460
gallaher@unavco.org

Christophe Gibson
Bahamas Department of Meteorology
Teachers and Salaried Workers Co-operative Credit Union's Business Complex East Street – South, Nassau, New Providenece N8330 Bahamas
242-356-3734
christophe.gibson@bahamasweather.org.bs

Omari Graham
The University of the West Indies
Seismic Research Centre
Gordon Street
St. Augustine, St. George 0000
Trinidad and Tobago
1-868-662-4659
omari.graham@uwiseismic.com

Marco Guzmán-Speziale
Centro de Geociencias, UNAM
Querétaro, Querétaro 76230 México
+52 442 238 1104
marco@geociencias.unam.mx

Francisco Hernández
University of Puerto Rico
S-9 Calle Ilan-Ilan, Urb. Villa Sonsire
Mayagüez, PR 00681 Puerto Rico
7872229541
Francisco.Hernandez@upr.edu

Machel Higgins
Seismic Research Centre, UWI
St. Augustine, St. Augustine St. Augustines
Trinidad and Tobago
1-868-662-4659
machelhiggins@uwiseismic.com

Leslie Jasen Hodge
Department of Lands and Surveys
Government of Anguilla
P.O.Box 60
The Valley, AI2640 Anguilla
1-264-497-2424
leslie.hodge@gov.ai

Joel Joseph
CNIGS
Delmas, Port-au-Prince 509 Haiti
509 37 11 19 68
arjoey@hotmail.com

Russ Kelz
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230 USA
703.292.4747
rkelz@nsf.gov

Vladimir Kostoglodov
Universidad Nacional Autónoma de México
Instituto de Geofisica
Circuito Investigación
Ciudad Universitaria
Mexico, DF 04510 México
52(55)5622-4138
vladi@servidor.unam.mx

Peter La Femina
Penn State
406 Deike Bldg
University Park, PA 16802 USA
814-865-7326
plafemina@psu.edu

Alberto López
University of Puerto Rico –
Puerto Rico Seismic Network
Mayagüez, PR 00680 USA
1-787-265-3845
alberto.lopez3@upr.edu

Taunia Luevano
UNAVCO
6350 Nautilus
Boulder, CO 80301 USA
303.381.7550
luevaco@unavco.org

Lloyd Lynch
Seismic Research Centre
University of the West Indies
St. Augustine, W.I. 11111 Trinidad and Tobago
868 662 4659
llynch@uwiseismic.com

Jaime Magliocca
UNAVCO
6350 Nautilus
Boulder, CO 80301 USA
303.381.7510
magliocca@unavco.org

Julio Marquez
Simón Bolivar University
Lab GPS, Dpt. Earth Sciences, Edif. FE II,
Ofic. 316
Baruta, Caracas, Miranda 1080A Venezuela
0058-414-2412367
06-39861@usb.ve

Fernando Martínez-Torres
University of Puerto Rico at Mayagüez
Mayaguez, PR 00681 USA
787-519-7314
fernan.martinez.2@gmail.com

Glen Mattioli
UNAVCO
Boulder, CO 80301 USA
303-381-7500
mattioli@unavco.org

Charles Meertens
UNAVCO
6350 Nautilus Dr.
Boulder, CO 80301 USA
303-381-7465
meertens@unavco.org

Diego Melgar
Scripps Institution of Oceanography
9500 Gillman Dr
La Jolla, CA 92037 USA
8588224336
dmelgarm@ucsd.edu

David Mencin
UNAVCO
6350 Nautilus Dr.
Boulder, CO 80301 USA
303-502-7995
mencin@unavco.org

Oscar Andres Meza
Instituto Geográfico de Honduras
Tegucigalpa, Francisco Morazan 504 Honduras
99 66 14 67/224 12 87
omeza1257@hotmail.com

Jamie Miller
University of Texas Arlington
4430 CANTRELL ST
GRAND PRAIRIE, TX 750523446 USA
2148682851
jamie.miller@tccd.edu

Carlos Minjarez
University of Arizona & Universidad de Sonora
Pricada Alsace No. 20
Hermosillo, Sonora 83280 Mexico
52 662 1530755
minjarez@email.arizona.edu

Hector Mora-Páez
Colombian Geological Survey
Diagonal 53 # 34-53 Geology Building
Room 214
Bogotá, D. C. 11001000 Colombia
5712200052
hmora@ingeominas.gov.co

Alicia Naimool-Ramdass
Lands and Surveys Division,
Trinidad and Tobago
118 Frederick Street
Port of Spain, Trinidad
8687359545
lrmp@tstt.net.tt

Rebecca Neill
University of Houston
2411 Coachlight Lane
Conroe, TX 77384 USA
832-628-3544
rebecca_neill@att.net

Jim Normandeau
UNAVCO
6350 Nautilus Drive
Boulder, CO 80301 USA
3033817475
normandeau@unavco.org

Jesse Ortega
University of Houston
414 Stratford St. Apt 4
Houston, TX 77006 USA
8326282587
jesse.a.ortega@gmail.com

Jasen Penn
Disaster Management
#3 Wailing Road, MacNamara
Road Town, Tortola VG1110 Virgin Islands
284-468-9665
japenn@gov.vg

Omar Pérez
Simón Bolivar University
Dpt. Earth Sciences
Baruta, Caracas Capital District 1080A Venezuela
00584166256426
ojperez@usb.ve

Eugenio Polanco Rivera
Instituto Sismológico, Universidad Autónoma de Santo Domingo
Santo Domingo, D.N., Distrito Nacional 10201
República Dominicana
1809-687-5349, 1809-501-3715 cell
eugenio_polanco_rivera@msn.com

Marino Protti
OVSICORI-UNA
Apartado 1718-3000
Heredia, Heredia 3000 Costa Rica
(506) 2562-4001
marino.protti@gmail.com

Rafael Pujols
ISU/UASD
Ciudad Universitaria
Santo Domingo, Distrito Nacional 1533
Dominican Republic
809-485-8879
rafaelpujols@hotmail.com

Félix Rivera
University of Puerto Rico, Mayagüez Campus
Western Lake Village
Mayagüez, PR 00682 USA
787-486-1871
felix.rivera12@upr.edu

Carlos Rodríguez
Global Matrix Engineering Puerto Rico – Dominican Republic
Ave 4ta Res. Santa Maria Apt 4G
Santo Domingo Este, Santo Domingo 10700-11999
Dominican Republic
829 645 9490
carlos.rodriguez@globalmatrixeng.com

Manuel Rodríguez Maradiaga
Instituto Hondureño de Ciencias de la Tierra/UNAH
Tegucigalpa, FM 11101 Honduras
(504)3204-2158
manuelr@uwalumni.com

Tatiana Rodríguez Tobar
Instituto de Hidrología, Meteorología y Estudios Ambientales
Carrera 13 No. 31-71 Apto 403 Torre A
Bogotá D.C. , Cundinamara 110311 Colombia
573013886874
ATrodriguez@ideam.gov.co

Ricardo Rosado
University of Houston
4369 Varsity Lane Apt A
Houston, TX 77004 USA
832-343-7353
r_rosado@mail.com

Lenine Christian Rousseau
State University of Haiti / Faculty of Sciences
270 rue Mgr Guilloux
Port au Prince, Ouest HT 6111 Haiti
(509) 36875901
lcrousseau@gmail.com

Linda Rowan
UNAVCO
6350 Nautilus
Boulder, CO 80301 USA
303-381-7571
rowan@unavco.org

Armando Saballos
Instituto Nicaragüense de Estudios Territoriales (INETER)
INETER, Frente a Hospital Solidaridad
Managua, 2110 Nicaragua
(505)-85993801
saballos76@yahoo.com

Gabriel Saenz
University of Houston
2201 W. Orem Apt.134
Houston, TX 77047 United States
915.471.7565
gsaenz7@miners.utep.edu

Patricia Sánchez
RSMAS, University of Miami, Florida, USA
6001 SW 70th St. #311
South Miami, FL 33143 USA
787-407-4303
psnchezrod@gmail.com

John Sandru
UNAVCO
4935 Twin Lakes Rd
Boulder, CO 80301 USA
907-750-9955
sandru@unavco.org

Andrea Sealy
Caribbean Institute for Meteorology and Hydrology
St. James, BB23006 Barbados
(246) 248-6764
asealy@cimh.edu.bb

Giovanni Sella
NOAA-NGS
1315 East-West Hwy, Locy Hall
Silver Spring, MD 20910 USA
301-713-3198x126
Giovanni.Sella@noaa.gov

Yolande Serra
University of Arizona
1118 E. 4th St., P.O. Box 210081
Tucson, AZ 85721-0081 USA
520-621-6619
serra@email.arizona.edu

Donald Simon
Antigua & Barbuda Meteorological Service
St. Johns, Antigua & Barbuda
268-764-2143
don_acs@yahoo.com

Kevin Tankoo
University of the West Indies, Mona Campus
Department of Geography and Geology,
University of the
West Indies
Mona, Kingston 7, St. Andrew JMAAW15 Jamaica
1-876-316-9335
kevintankoo@gmail.com

Uri ten Brink
USGS
Woods Hole Science Center - USGS
Woods Hole, MA 02543 USA
(508) 457 -2396
utenbrink@usgs.gov

Angel Terán
Servicio Meteorológico Nacional
Distrito Federal, Mexico 11860 México
(5255)26364646
angel.teran@conagua.gob.mx

Marguerite Toscano
Smithsonian Institution
Dept. of Paleobiology, NMNH MRC 121, PO Box 37012
Washington, DC 20013-7012 USA
202 633 1649
toscanom@si.edu

Oscar Tovar
UNAM
Cda, de Atliculco 23
México, Distrito Federal 12300 Mexico
+52 55 55598937
benitovel@hotmail.com

Teresa Van Hove
UCAR
3434 Mitchell Lane, FL4
Boulder, CO 80301 USA
303-497-8023
vanhove@ucar.edu

Bob Wang
University of Houston
R&S Building 1, Room 321, UH, 4800 Calhoun Rd
Houston, TX 77204 USA
713-893-1281
gwang@uh.edu

Robert Watts
Seismic Research Centre, UWI
St. Augustine, Port of Spain - Trinidad & Tobago
1 868 662 4659
Robwatts@uwiseismic.com

Michael Whiteman
Cayman Island Government
PO Box 1089
George Town, Grand Cayman KY1-1101 Cayman Islands
(345)244-3413
michael.whiteman@gov.ky

Colleen Wint-Smith
Caribbean Knowledge and Learning Network, CKLN
Mutual/Transnewmwil Office Complex, The Villa
St. George's, NA 00000 GRENADA
(876) 370-3628
colleen.wintsmith@ckln.org

Jiangbo Yu
University of Houston
5800 Gulfton Street, Apt1634
Houston, TX 77081 USA
8326185990